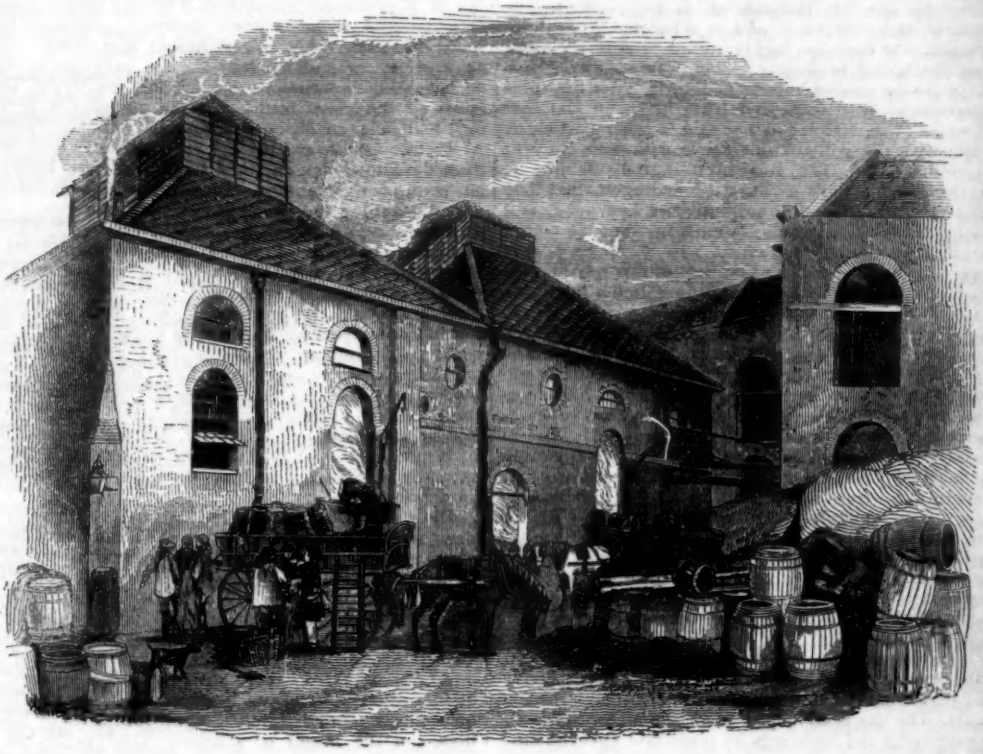
A DAY AT THE WESTMINSTER GAS-WORKS.



[Gas-Works—Horseferry Road.]

WHAT Dr Arnott says of the water-pipes of London, ramifying through every street, and lane, and alley, and distributing their valuable contents to the dwellings of its inhabitants, we may to a certain extent say of the pipes through which our supply of gas is obtained. "The supply and distribution of water in a large city, since the steam-engine was added to the apparatus, approaches closely to the perfection of nature's own work in the circulation of blood through the animal body. From a general reservoir a few main pipes issue to the chief divisions of the town; these send suitable branches to every street, and the branches again divide for the lanes and alleys; while at last into every house a small leaden conduit rises, and, if required, carries its precious freight into every apartment, where it yields it to the turning of a cock." The analogy is true so far as regards the emanation from a centre, the branching out of minor pipes from those of larger diameter, the lateral small pipes leading into the houses, and the concealment of the whole assemblage beneath the pavement and road-way; but the subsequent movement from the branches back again to the centre, though observable in the flow of water through drains into the rivers and seas, the evaporation from thence, and the feeding anew the springs from which the supply was originally obtained, is not so observable in the gas circulation.

Be the analogy what it may, however, no thinking person can fail to be struck with the admirable means whereby our cities and towns are now lighted. So far back as the year 1823, when gas companies were comparatively in their infancy, a Committee of the House of Commons spoke highly of the system of lighting streets by gas, as a measure of street police; and there can be no question that the doers of evil, who "love darkness rather than light," infest the streets of London not only relatively, but positively less now than before the introduction of gas, although the inhabitants have increased three or four hundred thousand in number. The beauty and convenience of the light afforded by gas in streets, shops, and buildings, are appreciated by all; but the protection which it gives, though not so fully understood, is not less worthy of notice.

In a former volume of the Magazine, a few papers were inserted with a view of giving an outline of the gas-manufacture, the machinery employed, and the scientific principles on which the gas is produced from coal. Our present object is, in conformity with the general nature of these Supplements, to be rather graphic than scientific, to select some one establishment of note, and to describe the general economy of the place, without entering very deeply into technical detail. The articles to which we allude are in Vol. III., Nos. 159, 166, 169, 170, and 174; and the reader will find in the first of these, a sketch of the history of gas-lighting; in the next three, some details of the manufacture of gas from coal; and in the last, a notice of the manufacture of oil-gas (since then almost abandoned). These papers are illustrated by about twenty wood-cuts of the working details, an inspection of which will greatly assist in imparting clear ideas on the matter. As this article may, however, fall into the hands of readers who have not the former numbers to refer to, we shall give a line or two here and there explanatory of the uses of

different parts of the apparatus, and may as well at once enumerate the successive steps or stages in the process. 1st. The carburetted hydrogen, which constitutes the gas for illumination, is one of the ingredients in common coal, and is separated from it by distilling the coal in highly heated vessels secluded from the access of the air. 2nd. The substance left behind in the heated vessels or retorts, after the volatile portions have separated from it, forms the fuel known as coke, which is either sold to other parties, or is used, with or without admixture with coals, to heat the retorts. 3rd. The volatilised ingredients are so far from being pure carburetted hydrogen, that they comprise tar, ammonia, sulphuretted hydrogen, and other substances, all of which must be removed before the light-producing ingredient will be in its proper degree of purity; and the first part of this purification is effected by a piece of apparatus called a hydraulic main, in which the coarser impurities are deposited. 4th. The gaseous product passes through pipes, which are either immersed in cold water, or are sprinkled by a jet of cold water externally; whereby all the impurities which are in the gaseous form only at high temperatures are condensed, and fall into a vessel beneath; hence this process is called condensing. 5th. The remaining gas contains sulphuretted hydrogen as well as carburetted hydrogen; and in order to remove the former, the whole is agitated in a vessel containing either lime or lime-water, which combines with the deleterious ingredient, and leaves the carburetted hydrogen tolerably pure. 6th. The gas thus made is conveyed through pipes to immense store-vessels called gasometers or gas-holders, where it is kept out of contact with the atmosphere by inverting the vessel in a tank of water. 7th. The gas passes through a meter or measurer, whereby the whole quantity made throughout a given period, and the rapidity of formation at any particular point of time, are determined. 8th and lastly. The gas is conveyed from the meter to the various streets and buildings by pipes laid underground, the supply being regulated to the demand by gauges and valves placed near the meter.

The establishment to whose arrangements the details of this paper are devoted is the Westminster station of the "Chartered Gas-light and Coke Company," which we have visited by the obliging permission of the directors. It bears in many respects the same relation to the gas-manufacture which the Soho factory bears to the steam-engine manufacture. It was the establishment which first had to bear the brunt of all the obstacles attending the public use of gas, the difficulties in the production of gas sufficiently pure for purposes of illumination, the difficulties attending the transmission of gas from the works to the houses and buildings, the enormous expense involved in the prosecution of experiments, and—perhaps the most difficult of all—to overcome the prejudices existing in the public mind. In the articles before noticed, it is stated that a Mr. Winsor, after lecturing on the subject at the beginning of the present century, formed a "National Light and Heat Company," which, though built upon rather fanciful grounds by the projector, became the parent of all the gas companies, and has ever since taken the lead among them. The works were established at Westminster, forming a portion of the present large station there. Mr. Matthews, who wrote a history of gas-lighting about fifteen years ago, takes the following view of the establishment of Mr. Winsor's company, which had become a chartered body:—"Various and plausible as were the objections urged against it at the time, experience has proved that the property of any individual was neither adequate to the magnitude, nor likely to be risked in such large and expensive undertakings; and this was shown by some facts adduced in the evidence to support the bill. By calculations that were made from actual surveys, it appeared that the expense of laying down pipes for the city of Westminster alone would be one hundred and fifty thousand pounds, without including anything else. There were also other circumstances that entitled this company to particular attention; for, previous to this period, their experiments for making, purifying, and applying the use of coal-gas to the purposes of lighting, had been made on a large and expensive scale. And although the public had been partially benefited from the knowledge obtained by their means, hitherto no pecuniary advantage had resulted to themselves, notwithstanding their zealous exertions to improve and introduce the art of gas-lighting. However, the hope of future benefits animated them in their further efforts to attain their object. Perseverance enabled them to overcome the great difficulties which attended their pursuits; the success of their endeavours has excited and encouraged others to engage in the same course, and imitate their example; and how many similar companies may trace their origin to the stimulus produced by the successful establishment of this!" The buildings which had been erected at the Westminster station before Mr. Matthews wrote, together with those which have been subsequently added, have cost no less a sum than three hundred and fifty thousand pounds.

The western station of the Chartered Company (the other two stations being at St. Luke's and near Shoreditch) occupies an oblong plot of ground, upwards of three acres in extent, lying on the northern side of the Horseferry Road, at no great distance from the Millbank Penitentiary. It was probably in the open fields when first built; but streets have been gradually formed around it. The general arrangement of the buildings is this:—there are two open squares or quadrangles connected by an arched passage; both the quadrangles are surrounded on all four sides by buildings, and the larger or southern quadrangle has in addition a large isolated building occupying its centre. The various masses of buildings have been erected at different times, as the operations of the Company extended, and serve as a kind of memento of the successive steps by which this great social improvement has been wrought.

On passing through the entrance gates from the Horseferry Road, we see on the right hand a range of offices and counting-houses called collectively the 'Coke-Office,' while another range on the left hand is occupied as the 'Light-Office.' In these ranges of buildings are the offices for the Committee of Management, the superintendent, the clerks, and others engaged in counting-house duties. The terms 'coke-office' and 'light-office' relate to the two great departments into which the operations of most or all gas companies are separated; for the sale of the coke produced in the manufacture of gas, though certainly subordinate to that of the gas itself, is an item of great importance, and received a proportionate share of attention. If coals could be brought to the London market at a price somewhat proportionate to that demanded at the pit's mouth, the sale of coke would not be looked to as a matter of so much importance; but the enormously high price which London manufacturers of every kind, as well as private persons, have to pay for coals, renders it necessary for the gas manufacturer to attend to the production of coke, either for heating the retorts or for sale. The kind of coal employed is selected not with relation to the absolute quantity of gas which it will yield, but with reference to its yielding both good gas and good coke. In our common domestic fireplaces we know that one kind of coal will concrete into a mass by a sort of

semi-fusion, forming cinder; while another sort will burn away to a white ash without producing cinder. Similar differences exist in the combustion of coal in retorts; and the gas manufacturer for the most part rejects that quality which will burn away to a white ash. One portion of the coke produced at the Westminster station is afterwards used in the ovens or furnaces to heat the retorts, and the remainder is sold to manufacturers, dealers, and private persons. The 'coke-office' is the place where all the arrangements connected with the sale of the coke are carried on; while the clerks in the 'light-office' similarly manage the dealings of the Company with the gas consumers.

The two offices just named lie at the southern end of the large quadrangle or court; and from them we will proceed to the other buildings, turning to the right after passing the entrance-gates. At and adjacent to the south-east corner are four of those bulky vessels which form the most conspicuous objects in a gas-factory. The term *gasometer* applied to these vessels is a very inappropriate one, inasmuch as it conveys an idea of measurement as connected with the purpose of the vessel; whereas the gasometer is in truth nothing more than a gas-holder, in which gas may be accumulated and stored. In the earlier history of the manufacture, however, the gas-holder was made to serve the purpose of a gas-measurer, by the addition of a scale of feet and inches, so that the depth of gas in the vessel, multiplied by its area, gave the cubic contents; and thus the term 'gasometer' became introduced. So far as regards the quality and efficacy of the gas, a gasometer might be dispensed with, the gas being conveyed at once from the purifiers to the mains and burners; but it would be impossible thus to regulate the supply to the varying demand. As a shopkeeper provides a store of goods more than sufficient for immediate demand, in order that he may be prepared for future fluctuations; so must the gas-works accumulate during the daytime a quantity of gas adequate to the enormous and sudden demand which occurs about dusk. From the first establishment of gas-works it was found necessary to provide this reserve store, but it was hoped that some means would be discovered of dispensing with the bulky gasometers. Such means have, however, not been found, and all the gas-works exhibit these capacious reservoirs. At the Westminster works there are no fewer than twenty of these, a larger number, we believe, than has been congregated in any other place, although some establishments have individual gasometers of larger capacity. Persons to whom the arrangement of gas-apparatus is not familiar are often surprised at the different appearance which a gasometer, as seen towering above the wall of a gas-factory, presents at different times. At one period a kind of scaffolding of light and elegant iron-work is seen, forming a triangular space, within which an enormous cylinder stands at a small height from the ground; at another time, perhaps, after an interval of a few hours, the cylinder will be seen to have ascended ten or twelve feet; and at a subsequent period to have ascended nearly to the top of the framework forty or fifty feet in height. These differences may be easily understood if it be borne in mind that a gasometer consists in reality of two vessels, one within another, the outer one being a tank open at the top and closed at the bottom, and the inner one being an inverted vessel open at bottom and closed at the top. The tank is filled to a certain height with water, into which the inverted vessel dips, so that the interior of the latter is cut off from communication with the external air by the interposition of the water. A pipe passes into the tank quite through the water, and terminates in the vacant space within the cylinder; and through this pipe the gas, when completely made and purified, is conducted. Now as carburetted hydrogen (common gas) is not half so heavy, *i.e.* has not half the specific gravity of atmospheric air, a certain bulk of it collected in the cylinder gives an ascensive power to the latter, notwithstanding the ponderous character of the metal; and the cylinder rises higher as the quantity of the contained gas increases. Balance-weights are suspended outside the gasometer to counterbalance in a certain degree the weight of the iron cylinder; and these weights are so adjusted as to give to the gas a pressure or elastic force slightly greater than that of the atmosphere. The reason of a gasometer rising, then, when full, is that the iron gasometer with its included carburetted hydrogen is lighter than an equal bulk of atmospheric air.

The tank of a gasometer is made of cast-iron, while the gas-holder is formed of sheet-iron, the sheets being riveted at the edges, and a piece of string being inserted at every joint, to make it air-tight—a simple but valuable contrivance suggested a few years ago by a workman. In some cases a strip of tarred canvas is inserted at the joints, or else canvas coated with white lead.

The four gasometers described as occupying the south-east corner of the quadrangle have what is termed the telescope construction, in which there are two gas-holders, one within another, and both within the tank; the inner gas-holder is filled first, and then, by an ingenious contrivance, elevates the outer one as the gas continues to enter; the object being to gain a greater capacity without increasing the diameter of the vessels, since the increased height of the apparatus is not so costly as an increased ground area. The tanks of these gasometers are about forty feet in diameter and eighteen feet high; and the gas-holders when full reach to a height of nearly forty feet. About twenty years ago there were some strange misconceptions afloat respecting the danger to be apprehended from the explosion of gasometers; but in the Report of a Committee appointed to investigate the matter, the following remark set the doubts at rest:—"As long as every part of this reservoir is kept in good repair and perfectly tight, the pipes leading into and out of it maintained in proper condition, and plenty of water supplied, so that the parts which should be under water shall never be left bare, it seems to your Committee scarcely possible that any explosion should take place." The experience of subsequent years has shown that the gasometers are perfectly safe, and they are now made of much larger dimensions than any known at that time. The average capacity of the four alluded to above is about forty-five thousand cubic feet each.

Proceeding northward along the right-hand boundary of the quadrangle, we come to other gasometers enclosed in brick buildings. In the infancy of the gas manufacture, when this establishment was making varied and costly experiments as to the best mode of conducting the operations, it was at first supposed that the gasometers ought to be not only bounded by brick walls, but covered with roofs. Experience has since shown that these expensive additions are not necessary; but the brick buildings (though now roofless) still remain, and serve as a memento of the gradual steps by which excellence and economy have been reached. Great indeed is the change since the time when second-hand brewers' vats were used as gasometers!

Between or adjacent to the gasometers are cisterns whose use curiously illustrates the branches of commerce which arise out of the gas manufacture. We have slightly noticed, and a reference to our former numbers will render more clear, the separation of a

liquid containing the alkali ammonia, from the other products of the combustion of coal. This ammoniacal liquor was at first a trouble and a burden to gas manufacturers; but after a time a market was found for it, and it is now regularly purchased by the proprietors of chemical works, as a source whence ammonia, or some of its compounds, may be obtained. The tar, which is another product of the combustion of coal in retorts, and of which more than a hundredweight is produced from a chaldron of coals, is separated from the gas by the same process, and in the same vessels as the ammoniacal liquor, and is in fact mixed with it; but as the tar has greater specific gravity than the ammoniacal liquor, it gradually assumes the lowest place in the vessel, and is then easily separated. Different plans have been adopted at different establishments in appropriating the tar thus produced; some sell it at once, as fast as it is produced; some consume a portion of it as fuel in the retort-house; while others, by a process of distillation, separate it into a volatile oil or naphtha, a fixed oil, and a solid residue commonly known by the name of pitch.

Northward of the gasometers and the tar and ammonia-vessels is a roofed building called the 'condensing or purifying house,' filled with a complicated series of vessels, employed, first, in condensing all those impurities which are capable of condensation, and secondly, in purifying or separating the gas from a portion of sulphuretted hydrogen which is always produced with it, and which, besides interfering with the brilliancy of the light, would produce a most disagreeable and unwholesome odour. Condensers of a great variety of forms have been used at different times and in different establishments; but those at the works under consideration consist of a pipe with a number of ascending and descending bends in it, and short pipes at the lower end to allow the tar and ammonia to flow out. A constant stream of cold water is flowing down the outside of each pipe, by which the gas, as it passes through, is cooled, and the condensible impurities separated from it. From the condenser the gas passes to the purifiers, of which there are three complete sets in the purifying-house, each set consisting either of three or four large cast-iron vessels. Referring to our former articles for a fuller detail, we may here merely state that the three or four purifiers forming one set are placed side by side, but at different elevations; that each vessel is supplied with lime-water, which is kept constantly stirred by a revolving apparatus within; that the gas passes successively through all the vessels, parting as it goes with its sulphuretted hydrogen, which combines with the lime-water. The lime-water is changed frequently when it becomes too much sulphuretted, and matters are so arranged that one bushel of lime will purify twenty thousand cubic feet of gas.

In immediate connection with the building in which the condensing and purifying processes are conducted is an Artesian well, for supplying the establishment with water, of which a considerable quantity is required. The well is in the old form, excavated and bricked, to a depth of a hundred and twenty feet, after which it is continued by an Artesian bore to a further depth of a hundred feet. This is one among the instances which will probably be greatly multiplied in future, of the substitution of a small bore in place of an expensive excavation; and rests on a principle which has been before explained in this work, viz. that if the watery stratum lying between the clay and the chalk be reached, a small bore is nearly as effectual as a well several feet in diameter.

The rotating machinery in the purifying vessels, the working of the pump in the well, and the removal of the tar and ammoniacal liquor from one vessel to another, are effected by steam-power, which is afforded by two steam-engines, one situated under the roof of the purifying-house, and the other in the building occupying the central portion of the quadrangle. The connecting machinery by which this power is transferred to the purifiers comprises the usual arrangements of shafts, bevel-wheels, straps and bands, &c., and gives a busy appearance to the building.

The next building to the purifying-house is one in which the sulphuretted lime undergoes certain processes, after being removed from the purifiers. Some of the most important improvements in the gas manufacture relate to this part of the proceedings. The lime-water is conveyed from the purifiers to a large underground cistern, and from thence to a range of cast-iron vessels, in what is termed the 'pug-mill room,' where it is allowed to settle, by which the principal part of the lime subsides and separates from the sulphuretted liquor. The lime is then taken to a 'pug-mill,' a sort of a churn, and there mixed up with clay, to form a cement or 'lute' for securing the covers of the retorts. The liquor is wholly evaporated, or driven off in the form of steam, by pouring it into shallow pans occupying the floor of the furnaces or ovens in which the retorts are heated. This mode, so far from being inconvenient, is productive of benefit in another way; for the steam arising from the liquor tends to cool the bars of the furnace, and thus to preserve them.

Next to this building is a carpenter's shop, in which wood-work for various purposes connected with the factory is made and adjusted. Adjoining this is a store-room for fire-bricks (used in the retort furnaces) and some other articles; and in the open area in front are two large vessels, called saturators, through which the whole of the gas passes after leaving the purifiers and before being conducted to the gasometers. The gas is, by a peculiar arrangement, subjected to a chemical process which gives it a very high degree of purity, by abstracting all the ammonia. This is a very recent improvement, under a patent obtained by Mr. A. Crole, superintendent of the Brick-lane station of this company.

We have now passed along the eastern side of the large quadrangle, from the north-east corner of which our frontispiece is taken. The building which occupies the principal part of the sketch is the central building before alluded to, through openings in which some indications may be seen of the fiery nature of the operations within. The buildings at the right are those on the western side of the quadrangle; while the foreground gives some idea of the busy scene which the whole place presents: here waggons laden with coals and passing to the coal-stores; there waggons and carts belonging to dealers in coke, who have come to purchase; in one place heaps of iron pipes; in another, of retorts, about to be put in the place of old ones; while men are bustling about in all directions. In crossing over to the western side, past the end of the central building, we catch an end glimpse of two of the retort-houses, such as is sketched in the following cut: through a dark arch the eye can just discern the movements of men passing to and fro in front of the retorts, while an occasional gleam from the retorts themselves suddenly lights up the spot.

The western side of this quadrangle is occupied almost entirely by gasometers, enclosed in brick buildings without roofs. A portion of the space is however occupied as a coal-store, one of the many receptacles for the vast quantity of coals consumed here. A contemplation of such immense supplies of fuel, and of the invaluable services derived therefrom, brings to mind the remark of an elegant writer, that the coal-mines of Britain "are, in effect, mines of labour or

[End View through Retort-house.]

power, vastly more precious than the gold and silver mines of Peru, for they may be said to produce abundantly everything which labour and ingenuity can produce, and they have essentially contributed to make her mistress of the industry and commerce of the earth. Britain has become to the civilised world around nearly what an ordinary town is to the rural district in which it stands, and of this vast and glorious city the mines in question are the coal-cellars." Fears have been entertained by some that the time must be looked forward to when this precious supply will fail —when the mines, worked at their present enormous rate, will no longer yield their wonted product. But the more investigations are made, the more remote seems to be the time when such a misfortune will befall us; and we may safely leave to future ages the adoption of a remedy, if not a prevention.

We will for the present leave unnoticed the central building in the large quadrangle, and proceed through an arched entrance into the inner court, which is much smaller than the other, and without any central erection. On the right of the entrance is a store for timber and other materials. At this part of the premises is another series of condensing and purifying apparatus, comprising vessels similar to those before described, as well as an ammonia tank, pumps, &c. Beyond these, on the right, is a large smiths'-shop, where men are busily engaged in the repair and adjustment of various articles used in different parts of the works. The gasometers, condensers, purifiers, tanks, retorts, mains, pipes, and other iron-work of magnitude, are of course made at the large foundries, but there are abundant demands for smiths'-work on a smaller scale at such an establishment as this. Beyond the smiths'-shop is another coal-store, and near this is the northern entrance to the works from Peter Street.

The northern end of this smaller court is occupied principally by one gasometer, the largest in the establishment, having a capacity of eighty thousand cubic feet: it is well placed, and has an imposing appearance, especially when raised to a height of fifty or sixty feet, as it was when we saw it. On the left or west side of the court are two of the four retort-houses iron-roofed buildings, in which the gas is made. The arrangement of these houses we shall speak of presently, and need only say here that these two present the same striking and remarkable features which characterise the other two. In the open court of the quadrangle are indications of the same traffic and bustle which the other presents: the arrival and unloading of cargoes of coal, the heaping and sprinkling of the heated coke just brought smoking and steaming from the retort-house, &c. At various convenient places in this, as in the other quadrangle, are store-houses for coal, from whence the retorts are supplied; and in addition, wherever room could be found for them, gasometers are placed, to the number, in all, of twenty-one.

We have now noticed the principal buildings, apparatus, and general arrangements round both quadrangles of the establishment, and will next return to the one first described, and take a hasty glance at the building in its centre. This building is divided into various departments, such as a deputy superintendent's office, an inspector's office, a meter-room, a valve-room, two retort-houses, a coal-store, a coke-store, an engine-room, &c. The four first-mentioned rooms form a kind of additional building attached to the southern end of the remainder, and, with its motto "STET CAPITOLIUM FULGENS," is the first object which meets the eye from the entrance. The retort-houses are built at a few feet distance from the ground, leaving space beneath for the coal and coke stores.

Whoever enters for the first time into a retort-house cannot fail to be struck with its appearance, so different from that of most other factories. The iron roof, the iron floor, the absence of windows, the absence of machinery and work-benches, the strange appearance of the walls speckled over with complicated iron-work (whose purpose is not clearly discernible), the dark-

ness of the place, the appearance of the men—all have an aspect of strangeness. But at intervals of every hour or two, and especially at night, the visitor's attention is suddenly awakened to a startling scene going on within the building. He sees a party of men advance to one part of the side apparatus; he sees them turn the handles of what appear to be screws; he hears several explosive reports, followed by the removal of circular iron doors or covers about a foot in diameter; he sees a burst of flame from each hole whence a cover has been removed; and on going in front of one of these openings (if he have courage enough) he will perceive a mass of intensely burning coal, or rather coke, extending back to the depth of six or seven feet. Then will follow the removal, by means of rakes, of all the burning materials from each opening; then the hissing and steaming consequent on the wetting of the coke by buckets of water; and then the re-charging of the heated cavity with fresh coals. It is not until after noticing this succession of operations that a stranger can rightly understand the arrangements of such a place. They are—with slight exceptions, which we need not heed here—as follows: Each side of the retort-house has a succession of arched recesses, each eight or ten feet high, six or seven wide, and about as many in depth. These recesses, when bricked or otherwise closed in front, form ovens or furnaces, in which fuel is burnt on a grate at the lower part. Five, six, eight, or more oblong iron vessels, each holding from two to three bushels of coals, are ranged horizontally in this oven, from front to back, so that the heat, flame, and smoke from the furnace may play around them, and make them red-hot. The outer end of these vessels, which are the *retorts* (a name for which we have never heard a good reason assigned), are left open or closed as occasion may require; an iron door, connected with a screw, being accurately fitted to each retort. The retorts (at the Westminster works) are semi-cylindrical in shape, with the flat side placed lowermost. The average height of the retorts is perhaps about five feet from the ground; under them is a fireplace, through which the fuel is introduced by which they are heated; and under this again is a kind of ash-pit or shallow vessel into which the lime-water is poured for the purpose of evaporation. The operation then consists in this:—The empty retorts are first brought to a red heat; then a 'charge' of coals is introduced; then the cover is screwed on the end, and made air-tight by a cement of clay and lime. Thus the retorts remain for about five hours, during which the fireplace is opened every hour for the renewal of the fuel (coke at these works) with which the retorts are heated; and at the end of this time all the gaseous and vaporisable matters having left the coal, and passed up from each retort by a pipe into the 'hydraulic main,' the 'drawing of the retorts' commences. The retort-cover is loosened by turning a screw; a slight explosion takes place when communication with the atmosphere is opened; the cover is removed by the sooty and almost fire-proof hands of the men, and the coke is drawn out by means of rakes eight or ten feet long. A kind of box, made entirely of iron, and placed upon wheels, is wheeled beneath the front of the retorts, and into it a portion of the fiery contents of each retort is drawn. The box is wheeled away, and in a few minutes volumes of steam are ascending profusely from it, the result of a plentiful supply of water, which is thrown on it for the sake of speedy cooling. The remainder of the coke is then drawn out on the iron floor of the building, and after being partially cooled by water, is removed out into the open air. While standing within a few feet of a party of men engaged in 'drawing' a group of seven or eight retorts, apparently unharmed and unconscious of a degree of heat which would scare others, we thought of Schiller's 'Road to the Iron-foundry;' the fate intended for poor Fridolin, but experienced by the envious Robert; "the heat which seemed as though it would melt rocks;" the chuckle with which the forgemen pointed to the manner in which their lord's orders had been executed; but it was satisfactory to think that neither a Robert nor a "gentle Fridolin" could be inserted in a gas-retort; nor are the stokers, though swarthy enough without, so black or so stony-hearted within as Schiller's forgemen.

The other arrangements of the retort-houses may be understood with tolerable clearness by a reference to our former papers, and we shall therefore devote only a few lines to them. In the upper part of every retort is an opening from which ascends a vertical pipe three or four inches in diameter. The gas, as it is formed, having no other outlet, ascends this pipe, passes thence to another pipe placed horizontally, and then enters a descending pipe, which dips into a large main fourteen or fifteen inches in diameter. This main is placed horizontally along the whole length of the retort-house, and receives all the gas from the whole range of retorts on one side, there being two mains on opposite sides of each retort-house. In these mains commences that purification of the gas which is the object of four successive processes, carried on in four distinct kinds of apparatus, viz. the hydraulic mains, the condensers, the purifiers, and the saturators. As may be readily supposed, the transference of the various products—such as gas, tar, ammoniacal liquor, &c.—from vessel to vessel, requires a large assemblage of pipes, some of which are carried underground, and others within view.

The retort-houses, such as we have just described, are four in number; two situated in the northern quadrangle, and the other two being placed parallel and contiguous in the central building of the southern quadrangle. From these we pass to a series of smaller rooms attached to the southern end of the retort-houses, and within view from the entrance gates. One of these is the office of the deputy superintendent of the works, and the other two contain very ingenious specimens of apparatus whereby he can regulate the supply of gas at all hours of the day, calculate how much gas has been made within a certain period, ascertain the rate at which it is being manufactured at any particular time, and keep a check over the labours of the men. One of these rooms is called the 'valve-room,' and contains the apparatus for regulating the pressure and supply of the gas. To understand the use of such apparatus, it is necessary to recal to mind the striking change which occurs throughout London as evening is drawing on. The lamplighter is seen busily hastening from lamp to lamp, placing his slight ladder against the street lamp-irons, and kindling the flames which give to our streets no small share of their evening attractions; the shopkeeper begins to illuminate his wares, with one blaze if he be an humble dealer, with a dozen if his house be a 'gin-palace,' with a score or two if he sells 'unparalleled bargains' in linen-drapery; the theatres, the club-houses, the evening exhibition-rooms—all begin to display a blaze of light near about one time. Now it must be obvious that the sudden demand thus created is enormous, and it may easily be conceived that great judgment is required in adjusting the supply. In order that the gas may be propelled through the main-pipes from the factory to the remotest point supplied from the works, it is necessary to give the gas a pressure or elastic force greater than that of the atmosphere. If this pressure be too small, the lights at remote places would burn much too faintly; if too large, the flames would become so strong as to consume an inordinate

quantity of gas; if the gas flowed from the gasometers at an hour before dusk at the same rate as at an hour after dusk, the utmost confusion and irregularity would occur. To obviate these evils is the object of the pressure-apparatus. Around the valve-room are placed valves connected with each great main. There are six mains branching out from the factory in as many different directions, for the supply of different parts of town; and as each main requires a supply of gas proportionate to the nature and extent of the district through which it passes, a pressure-apparatus is attached to it distinct from the others. Directing our attention to one main only, we may state that after the gas leaves the gasometers and enters the main, it is placed in communication with a small tube leading to a 'pressure-indicator,' by which the exact pressure at any time of the day or night is determined. So long as the pressure is such as is required, no changes are made; but when it is either too great or too small, recourse is had to a valve, whose interior apparatus is in connection with the main. If the pressure is too great, the valve is drawn partly across the main, by which the supply of gas is slackened; if too small, the valve is opened more than before, to admit a greater volume of gas. These adjustments are, as was before observed, made in the 'valve-room,' every main having its own 'pressure-indicator' and its own 'valve.'

A room adjacent to the one just mentioned, and called the 'meter-room,' exhibits to view a cast-iron case of a very tasteful kind, represented in the cut at the end of this article. This case is probably about ten feet square, and seven or eight feet high, and occupies the centre of the room. On the front are six or eight small dials, like clock-faces, and at the back (not seen in the cut) are two pipes ascending through the floor, and entering the case. The case is decorated with much elegance, and the motto, "EX FUMO DARE LUCEM," expresses, not inappropiately, the light-giving object of the whole establishment. All the gas made at the works passes into this case or 'meter' by one of the pipes just spoken of, and leaves it by the other. The meter will contain a certain known quantity of gas; and while this quantity is passing through the machine, an index hand is caused, by mechanism within the case, to revolve once round a dial-plate. Every ten revolutions of this hand causes another index to revolve once round another dial-plate; ten of these latter revolutions caused one revolution of a third index; and so on through six successive stages, the last index revolving only once while a million cubic feet of gas are passing through the meter. The superintendent, by looking at the indications in these six dial-faces, is thus able to tell, even to a single foot, how much gas has passed through the meter to the main pipes. There are two other dials on the front of the meter, one of which is a regular clock, and the other an ingenious arrangement for showing the rate at which the gas is passing through the meter at any particular time.

The operations of a gas-factory, like those of a glass-factory, and even in a still greater degree, are interminable from the beginning to the end of the year. No cessation, even for a moment, occurs in the labours. One party of men are engaged at night; another party relieve them after an interval of twelve hours, and are employed by day; but the furnaces are always heated, the retorts always supplied with their fiercely burning contents, the gas always undergoing the purifying processes previous to its passage into the gasometers. The number of retorts worked varies at different seasons of the year, according to the length of time between sunset and sunrise; for the gas-manufacturer is regulated, more perhaps than most other manufacturers, by the movements of the sun. But whether the number actually worked at any one time be greater or smaller, the system pursued is nearly the same. At the Westminster works the retorts are so divided into groups that some of them shall be ready for 'drawing' every hour. If we suppose, for instance, that a charge of coals remains five hours in the retort, and that the retorts are divided into five parcels or sets, one set would be filled (say) at noon, another at one o'clock, and the rest at two, three, and four o'clock respectively. Then, by five o'clock the first set of retorts are ready to be drawn; at six o'clock the second set; and so on with the others. The precise arrangements we need not enter into, but it will suffice to say that exactly as the clock strikes each successive hour, the men loosen and remove the covers of the retorts, draw out a portion of the coke into large iron boxes, draw out the rest upon the iron floor of the retort-house, throw water on the coke preparatory to its removal from the retort-house, recharge the retorts with fresh coal, replenish the fires with a fresh supply of coke, and fit the covers—coated on their inner surface with a thick layer of lime and clay cement—firmly on the mouths of the retorts. In the intervals which elapse between the successive 'drawings', the men are employed in pouring the lime-water into the troughs beneath the fireplaces, in placing new layers of cement on the retort-covers to be used after the next drawing, in carrying out the coke into the open air, and afterwards into the sheds or stores, in bringing coals from the coal-stores to the retort-houses, in removing the ashes which fall into the lime-water in the ash-pit, and in various other duties subsidiary to the manufacture of gas. The subsequent preparation, or rather perfecting of the gas, demands but a small amount of manual labour; it is in fact performed by the steam-engine, which pumps up the water from the well, transfers from vessel to vessel the tar and the ammoniacal liquor abstracted from the gas, and sets in rotation the arms or fans in the purifying vessels.

There is perhaps no part of the gas mechanism which requires better workmanship and more careful attention than the pipes which convey the invisible agent from the works to the places where it is consumed. However perfect may be the mode in which the gas is manufactured, however plentiful the supply, yet if the pipes are either too small or too large, if they are laid either too horizontal or too much inclined, if any of the innumerable joints are imperfectly fitted, the most serious inconvenience results. The mains vary from three inches to eighteen inches in diameter, independent of the small lateral pipes which proceed from the mains into the houses. The largest mains are placed nearest to the gas-works; the next in size are appropriated to the leading streets and thoroughfares; while the smaller are for the less important lanes and streets. Where the streets are wide, and the number of lights required large, it is usual to lay mains on both sides of the street; and the diameters of these mains are made to depend not only on the magnitude and importance of the street, but on its elevation, its distance from the works, and other circumstances. There is a circumstance attended to in laying down the mains which is perhaps not generally known. They are laid with a gradual inclination, amounting perhaps to an inch in ten or twelve yards, instead of being horizontal; and when this slope has continued for one or two hundred yards, the mains begin to ascend in a similar degree. The line of mains thus ascends and descends alternately throughout its whole length. The reason for this arrangement is, that a small deposition of fluid takes place in the mains; and this fluid, by flowing down the inclined pipes, accumulates at the lower points, where two descending lines meet: here a reservoir is formed, into which the liquid flows, and by the occasional use of a small pump from above the inconvenience is removed.

How few persons would guess the length of these underground arteries! How few would suppose that the mains, proceeding from the Westminster works alone and ramifying through the streets at the west end of the town, would, if laid in a straight line, reach from London to Bristol; or, if combined with the 'service-pipes' which pass from the mains to the houses, extend from London to Exeter! Yet such is the case. Rapid as has been the erection of new houses, the extension of the gas-manufacture has proceeded with immeasureably greater rapidity. In the year 1814 there was only *one* gasometer at the Westminster station of the Chartered Company, then the only company in London; and this gasometer held only fourteen thousand cubic feet. By the year 1822, according to a Report on the various gas-works, presented by Sir William Congreve to the Secretary of State, the Westminster works had reached the following position:—"The whole number of retorts which were fixed was 300; the greatest number working at any time 221; the least number 87. Fifteen gasometers, varying in dimensions, the contents computed at 20,626 cubic feet each, amounting to 309,385 cubic feet altogether, but never quite filled. The extent of mains belonging to this station is about 57 miles; the produce of gas, from 10,000 to 11,000 cubic feet from a chaldron of coals. The weekly consumption of coals is reckoned at forty-two bushels for each retort, amounting to about 602 chaldrons; and taking the average number of retorts worked at this station at 153, would give an annual consumption of coals of upwards of 9282 chaldrons, producing 111,384,000 cubic feet of gas. The average number of lights during the year 1822 was 10,660 private, 2248 street lamps, and 3894 theatre lamps." In the interval which has elapsed since this Report was made, great extension has taken place in all the operations of the gas-manufacture. The Westminster station now contains about six hundred retorts; the twenty gasometers have an aggregate capacity of nearly eight hundred thousand cubic feet; the length of main-pipes exceeds a hundred and twenty miles, and of service-pipe fifty miles. The quantity of gas which leaves the works on a mid-winter's day is a million and a quarter cubic feet. As to the area of ground over which this quantity is spread, it may be best seen by taking a map of London, and tracing out a boundary, of which the northern part shall be Oxford-street, the eastern Temple-bar, the western Grosvenor-place, and the southern the Thames: the maze of squares, markets, streets, and lanes included within this boundary points out the scene of operations.

Whether or not we accept the motto used by Mr. Matthews in his work on Gas-Lighting,—

"This is an art which doth excel nature."

there is abundant room for admiration and congratulation in the history and application of this light-giving agent; and the following statement, from the 'Penny Cyclopædia,' shows how extensively the advantages are now appreciated:—"Every large town in Great Britain has long had gas; the smaller towns have followed, and there is now scarcely a place in the kingdom without it. The continental nations have slowly followed our example; Paris for some years, and more recently the towns of Lyon, Marseille, Bordeaux, Nantes, Caen, Boulogne, Amiens, and several others, have adopted it. It is in use in many parts of Germany and Belgium, and St. Petersburg has a small establishment which is rapidly increasing under the superintendence of a gentleman from one of the London works. The larger towns in the United States also burn gas; and even in the remote colony of New South Wales, the town of Sydney has introduced this valuable invention, which we have no doubt will be found there, as it has been in London, as useful in preventing nocturnal outrage as an army of watchmen."

[The Meter.]